OVERVIEW OF THE COMET ASTROBIOLOGY EXPLORATION SAMPLE RETURN (CAESAR) NEW FRONTIERS MISSION

D. P. Glavin[1], S. W. Squyres[2], K. Nakamura-Messenger[3], A. G. Hayes[2], D. F. Mitchell[1], V. E. Moran[1], M. B. Houghton[1], D. Douglas-Bradshaw[1], D. S. Lauretta[4], S. Messenger[3], K. Yamada[5], S. Okazaki[5], Y. Satoh[5], Y. Maru[5], T. Nakao[5], A. Kukita[5], T. Shimoda[5], T. Yamawaki[5], T. Nakamura[6], J. E. Parker[1], D. C. Wegel[1], H. L. Peabody[1], J. P. Dworkin[1], A. N. Nguyen (Jacobs)[3], S. Clemett (Jacobs)[3], T. J. Zega[4], E. Mazarico[1], D. Rowlands[1], S. A. Aslam[1], N. Gorius (CUA)[1], G. Quilligan[1], Y. Furukawa[6], Y. Kimura[7], A. Takigawa[8], G. Blake[9], M. J. Mumma[1], S. N. Milam[1], P. A. Gerakines[1], J. I. Lunine[2], J. L. Mitchell[3], L. F. Pace[3], C. D. K. Herd[10], S. Gorevan[11], J. Spring[11], K. Zacny[11], P. C. Chu[11], M. M. Hasegawa[1], C. Güttler[12], H. Sierks[12], J.-B. Vincent[13], N. Oklay[13], H. Campins[14], Y. Fernandez[14], J. Makowski[15], D. Oberg[15], E. L. Morse[15], J. M. Soderblom[16], D. Bodewits[17], M. Kelley[17], B. Davidsson[18], J. Johnson[19], A. Kulchitsky[19], R. Kirk[20], L. Leshin[21], K. Öberg[22], M. Ravine[23], and the CAESAR Project Team. [1]NASA Goddard Space Flight Center, Greenbelt, MD, USA, [2]Cornell University, Ithaca NY, USA (E-mail: squyres@astro.cornell.edu), [3]NASA Johnson Space Center, Houston TX, USA, [4]University of Arizona, Tucson AZ, USA. [5]JAXA/ISAS, Yoshinodai, Chuo, Sagamihara, Kanagawa, Japan. [6]Tohoku University, Sendai, Miyagi Prefecture, Japan. [7]Hokkaido University, Sapporo, Hokkaido, Japan. [8]Kyoto University, Kyoto, Kyoto Prefecture, Japan. [9]California Institute of Technology, Pasadena, CA, USA. [10]University of Alberta, Edmonton, AB, Canada. [11]Honeybee Robotics, Pasadena, CA, USA. [12]Max Planck Institute, Göttingen, Germany. [13]DLR Institute of Planetary Research, Berlin, Germany. [14]University of Central Florida, Orlando, FL, USA. [15]Northrop Grumman Information Systems, McLean, VA, USA. [16]Massachusetts Institute of Technology, Cambridge, MA, USA. [17]University of Maryland, College Park, MD, USA. [18]Jet Propulsion Laboratory, Pasadena, CA, USA. [19]Coupi, Inc., University of Alaska, Fairbanks AK, USA. [20]US Geological Survey, Flagstaff, AZ, USA. [21]Worcester Polytechnic Institute, Worcester, MA, USA. [22]Harvard University, Cambridge, MA, USA. [23]Malin Space Science Systems, San Diego, CA, USA.

Introduction: The Comet Astrobiology Exploration Sample Return (CAESAR) mission was selected by the NASA New Frontiers Program for Phase A study in December 2017. CAESAR will acquire and return to Earth for laboratory analysis a minimum of 80 grams of surface material from the nucleus of comet 67P/Churyumov-Gerasimenko (67P). CAESAR will characterize the surface region sampled, preserve the collected sample in a pristine state, and return evolved volatiles by capturing them in a separate gas reservoir. NASA Goddard Space Flight Center provides project management, systems engineering, safety and mission assurance, contamination control, mission operations, and many other important functions. Northrop Grumman Information Systems (formerly Orbital ATK) will build the spacecraft, based on Dawn mission heritage, which like CAESAR, uses solar electric propulsion.

Collection of a sample from the surface of comet 67P is facilitated by a set of cameras that together provide images to support sample site selection, perform optical navigation, and document the sample before, during, and after collection. The sample is collected at the end of an arm during a 5-second touch-and-go (TAG) maneuver with the Sample Acquisition System (SAS) designed by Honeybee Robotics for the surface properties of comet 67P observed by the Rosetta mission. After sample collection, and while the sample is still cold (< -80°C), the TAG Arm inserts the sample container into the Sample Containment System (SCS) mounted inside the Sample Return Capsule (SRC). The SCS is sealed, preventing the sample from escaping into space. The sample is slowly warmed inside the SCS to enable sublimation of volatiles, which are collected in the Gas Containment System (GCS), a passively cooled gas reservoir. Separating the volatiles from the solid sample protects the solid sample from alteration. Once all sublimated H_2O is transferred to the GCS, the GCS is sealed to capture the volatiles it contains, and the SCS is vented to space to maintain the solid sample under vacuum. The SCS vent is closed before Earth entry to prevent atmospheric contamination.

The CAESAR SRC is provided by the Japanese Aerospace Exploration Agency (JAXA). Its design is based on the SRC flown on the Hayabusa and Hayabusa2 missions. The SRC lands at the Utah Test and Training Range (UTTR) in November 2038 and is immediately placed in cold storage for transportation to the NASA Johnson Space Center, where the solid and gas samples are removed and delivered to a dedicated CAESAR curation facility.

Detailed laboratory analyses of the sample from 67P will trace the history of volatile reservoirs, delineate the chemical pathways that led from simple interstellar species to complex molecules, constrain the evolution of the comet, and evaluate the role of comets in delivering water and prebiotic organics to the early Earth. CAESAR will achieve these goals by carrying out coordinated sample analyses that will link macroscopic properties of the comet with microscale mineralogy, chemistry, and isotopic studies of volatiles and solids. Most of the sample (≥75%) will be set aside for analyses by generations of scientists using continually advancing tools and methods, yielding an enduring scientific treasure that only sample return can provide.